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LOCAL RESPONSES TO CLIMATIC DISASTERS: ADAPTIVE STRATEGIES FOR SUSTAINABLE LIVELIHOODS IN SATKHIRA, NAOGAON, AND KURIGRAM, BANGLADESH

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Abstract:
This study investigates the diverse livelihood options and adaptive strategies in response to disasters in the Satkhira, Naogaon, and Kurigram districts. The research identifies distinctive livelihoods in Satkhira, such as crab collection and shrimp culture, and in Naogaon, mango-related businesses. Disasters significantly impact income and livelihood opportunities, with Satkhira and Kurigram experiencing more severe disruptions than Naogaon. Adaptation strategies vary by district: in Satkhira, loan-taking, savings use, and diversification of income sources are predominant, whereas, in Naogaon and Kurigram, multiple earning sources and alternative livelihoods are prioritised. The study reveals low overall livelihood support, with Kurigram receiving the most effective and sustainable aid. Knowledge and demand for climate-resilient livelihoods remain low across all districts, underscoring the need for financial, technical,

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and training support to enhance resilience. The research highlights the critical necessity for targeted interventions to bolster livelihood resilience in these vulnerable regions.

Keywords: livelihood adaptation, disaster impact, climate resilience, adaptive strategies, rural livelihoods

1. Introduction

In recent decades, the frequency, intensity, and severity of climate-related disasters and extreme weather events—such as heavy rainfall, floods, cyclones, and droughts—have increased due to anthropogenic warming of the Earth's atmosphere and oceans (Sammonds, Shamsudduha, & Ahmed, 2021). Disasters are a primary global concern, and reducing disaster risk is an urgent priority for humanitarian and development communities worldwide (Schneiderbauer & Ehrlich, 2004). Bangladesh is a low-lying deltaic country universally recognised as highly vulnerable to climate-related disasters such as cyclones, floods, and droughts (Gray & Mueller, 2012), exemplifying the precarious balance between human livelihoods and environmental disruptions. Satkhira, Naogaon, and Kurigram districts present unique case studies of local populations' adaptive strategies to sustain their livelihoods amidst recurring disasters. Comprehending these strategies is essential for developing effective disaster management policies and enhancing resilience among vulnerable communities.

The southern and southeastern peripheral regions of Bangladesh are particularly vulnerable to tropical cyclones due to their low elevation, gentle slopes, proximity to the sea, numerous historical cyclone tracks, susceptible land cover (including settlements and cropland), and inadequate socio-economic structures (Hoquea, Pradhan, Ahmed, Ahmed, & Alamri, 2021). The district of Satkhira, situated in southwestern Bangladesh, is predominantly affected by cyclones and tidal surges due to its immediacy in the Bay of Bengal and the Sundarban mangrove forest. Recently, coastal cropland has been rendered unsuitable for agriculture and crop cultivation due to increased soil and water salinity. This high salinity infeasible crop production adversely impacts the entire coastal region. Shyamnagar Upazila, within the Satkhira district, is particularly affected by salinity (Rezoyana, Tusar, & Islam, 2023). A study found that salinity intrusion has severely impacted traditional livelihood options, leading 62.3% of individuals in the study area to change their livelihoods. The adverse effects of salinity on traditional practices have prompted the emergence of alternative livelihood options, such as shrimp farming, crab fattening, and day labour (Rezoyana, Tusar, & Islam, 2023). These measures reflect the community's capacity to innovate and adapt to environmental adversity. However, they also underscore the need for broader structural support to enhance resilience.

According to a study, Naogaon District in northwestern Bangladesh is already known as a drought-prone area (Rahman, Islam, Rimi, Islam, & Tusher, 2013). Dependent on rainfall as the sole source of moisture for crop and pasture growth, seasonal rainfall

variability inevitably leads to highly variable production levels. This variability has also given rise to risk-averse livelihood and coping strategies among rural populations (Cooper, et al., 2008). Farmers in Naogaon have responded by adopting water-efficient practices and diversifying their crop choices to include more drought-resistant varieties. The shift towards such adaptive agricultural practices illustrates the interplay between traditional knowledge and modern techniques in mitigating disaster impacts. Additionally, community-based organisations' ability to disseminate information and facilitate access to resources is critical in enhancing the adaptive capacity of households in this region.

Kurigram, a northern border district of Bangladesh, is bounded by Indian states and Bangladeshi districts and features over 20 rivers, including the Brahmaputra and Teesta, among Bangladesh's 405 rivers (Shahriar, 2021). Kurigram, located in the northernmost part of Bangladesh, frequently contends with riverine flooding due to its proximity to major river systems like the Brahmaputra and Teesta. The recurrent floods disrupt agriculture, damage infrastructure, and displace populations, necessitating robust adaptive measures. Livelihood strategies in Kurigram often include temporary migration to urban areas for alternative employment, the construction of raised homes and storage facilities to protect assets, and the cultivation of flood-resistant crops. These adaptive responses highlight the dynamic and often complex nature of coping mechanisms, where mobility, infrastructure adaptation, and agricultural innovation converge to address the multifaceted impacts of flooding.

Adaptive strategies in the Satkhira, Naogaon, and Kurigram districts showcase community resilience amid challenges. Integrating local knowledge with research is crucial. Context-specific approaches and investments in infrastructure are essential for policymakers. Lessons resonate globally, offering scalable solutions for climate adaptation and disaster risk reduction and supporting vulnerable populations in thriving.

2. Background and Rationale

The districts of Satkhira, Naogaon, and Kurigram in Bangladesh contend with recurrent natural disasters, each posing distinctive environmental challenges. Satkhira confronts cyclones and salinity issues, Naogaon faces droughts, and Kurigram contends with riverine floods. Understanding the adaptive livelihood strategies these communities employ in response to these conditions is imperative for developing effective disaster management strategies. This study seeks to offer insights into local adaptive measures, elucidating the resilience and innovative responses that can inform broader policy and support frameworks.

2.1 Research Objectives

This study investigates the adaptive strategies and livelihood practices employed by communities in Bangladesh's Satkhira, Naogaon, and Kurigram districts. The objective is

to understand how these communities cope with natural disasters, providing insights that can inform and enhance disaster resilience and policy interventions in similar contexts.

2.2 Scope and Significance of the Study

This study explores the adaptive strategies and livelihood practices in Bangladesh's Satkhira, Naogaon, and Kurigram districts. Examining how communities navigate natural disasters offers valuable insights for disaster resilience efforts and policy formulation, with global implications for similar vulnerable regions.

2.3 Limitations of the Study

Despite employing comprehensive methodologies, this study is subject to several limitations. Firstly, while the sample size is statistically derived, it may not fully encapsulate the diversity within each district. Secondly, reliance on self-reported data could introduce response biases. Thirdly, the focus on specific districts may restrict the generalizability of the outcomes to more significant perspectives. Additionally, the qualitative component's reliance on secondary documents and community reflections may introduce interpretation biases. Lastly, the brief duration of field data collection might limit the depth of insights obtained. These limitations warrant careful consideration when interpreting the study's findings and implications.

3. Literature Review

Bangladesh faces severe challenges due to climate change, primarily because of its low-lying geography. This makes it vulnerable to sea-level rises and extreme weather events such as temperature rises, food crises, droughts, floods, and cyclones. Despite contributing insignificantly to global emissions, the country is experiencing significant impacts, such as increased temperatures, shifts in rainfall patterns, and more frequent natural disasters (Mahmood , 2012). Along with other climate-vulnerable areas in Bangladesh, the districts of Satkhira, Naogaon, and Kurigram are prone to various natural disasters like cyclones, floods, droughts, and salinity intrusion (Islam M. , 2023), (Islam, Tamanna, & Amstel, 2021). Satkhira, being a coastal district, frequently faces cyclones, storm surges, and salinity intrusion, which have been intensified by climate change (Rabbani, Uddin, & Munira, 2021), (The Business Standard, 2024). Naogaon and Kurigram, while not coastal, are not immune to the impacts of climate change. These districts often suffer from riverine floods due to heavy rainfall and the overflow of major rivers (i.e., Januna and Dharla) passing through them. Besides, they also face drought, which affects agriculture and water availability. The combined effects of these natural disasters pose significant challenges to the residents, impacting their economy, health, and overall well-being (Tanni, Hossain, & Haque , 2022), (Roy & Sarker, 2016). Communities in these districts have employed various adaptive strategies, such as coastal mangrove restoration and the 'Forest, Fish, Fruit' model, which integrates fish

nursery ponds between trees to reduce the impact of cyclones and flooding while supporting livelihood diversification (Initiative, 2024). These nature-based interventions have been crucial in enhancing the resilience of coastal ecosystems and the adaptive capacity of local stakeholders. Besides, adaptive strategies involving crop diversification, homestead gardening, and integrating traditional knowledge with modern practices are common in these areas (Rahman M. M., Hossain, Ali, & Ahmed , 2022), (Alam, Alam, & Mushtaq, 2017). Socio-economic factors such as education, infrastructure, health facilities, and alternative livelihoods during extreme events significantly influence vulnerability and resilience to disasters in these areas (Ahsan & Warner, 2014). The poverty-vulnerability-resilience nexus suggests that while people with low incomes may be more vulnerable and suffer more severe damage, this does not necessarily lead to low resilience, as they may exhibit a more remarkable ability to withstand shocks compared to their non-poor neighbours (Akter & Mallick, 2013).

NGOs, CSOs, and other stakeholders are critical in disaster response. They assist public health and emergency planners in determining the capacity and capability of NGOs for disaster response and recovery. Their involvement ranges from strengthening natural hazard governance to mobilising local actors and promoting Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) perspectives (Gibson & Wisner, 2019).

Bangladesh's government has implemented several policies and interventions such as the National Adaptation Plan (2023-2050), Bangladesh Climate Change Strategy and Action Plan (BCCSAP), Delta Plan 2100, Mujib Climate Prosperity Plan (2022-2041) and others to address disaster risk reduction and climate change adaptation strategies. These policies aim to increase resilience against climate-related disasters and support long-term growth, recognising the country's successful experience with locally-led climate adaptation.

Besides, gender dynamics significantly influence disaster resilience and adaptive strategies. Women, men, youth, elderly, and persons with disability experience and respond to disasters differently, often reflecting and reinforcing gender inequality. Understanding these dynamics can lead to more adaptive and effective disaster risk management policies and interventions (Bank, 2021).

However, challenges and gaps remain in disaster management strategies. Issues of equity, accessibility, and sustainability are prevalent, with governance challenges impeding the effective implementation of disaster management programs. There is a need for increased public awareness, budget allocation for DRR, and collaboration between governmental and non-governmental entities to meet the Sustainable Development Goals (SDGs) and build resilient, sustainable communities (Islam, Karim, & Faisal , 2023).

Although resilience assessment has been conducted against many hazards, cyclones have been most emphasised. However, resilience against one type of hazard does not guarantee resilience against other kinds of hazards (Frankenberger, Mueller, Spangler, & Alexander, 2013), especially for the coastal region of Bangladesh, which is

highly exposed to different types of climate disasters and environmental problems such sea level rise, salinity intrusion, flood, erosion and arsenic contamination.

NbS can be leveraged to create a more resilient future by forming smart investment opportunities in nature and those that make green and clean jobs, deliver value for people, economies and nature, and accelerate ecosystem services as a tool for economic recovery (Murti & Sheikholeslami, 2021).

By living in hazard-prone areas and undergoing frequent natural hazards, local communities have advanced a multi-layered knowledge of disasters in their localities. Traditional knowledge has admitted communities to thrive and build capacity in challenging physical landscapes, multi-hazardous environments, and various socio-economic, political, and cultural contexts (United Nations Office for Disaster Risk Reduction (UNDRR), 2022).

To cope with the altering situation, smallholder farmers in the coastal regions are adopting diversification strategies on-farm (planting drought-tolerant crops and diverse farming) and off-farm (selling household assets, migrating entire households and decreasing food consumption/changing diets). These varied activities allow farming households to manage risk and improve their lives (Aniah, Millar Katherine, & Joseph A, 2019). Some factors, such as education level, number of livestock, farming experience, etc., affect the adoption of varied activities (Akhtar, et al., 2019). Most notably, the age of the household head, along with possession of cropland and distance from markets, are essential determinants of livelihood diversification strategy. An educated household head and other knowledgeable family members can easily distinguish the best alternative economic activities for the family's well-being by integrating on-farm and off-farm activities (Roy & Basu, 2020).

Education was a factor that had both a quick effect through training and a broader long-term effect through heightened competence, which aided in personal and societal preparedness for any probable natural hazard. (Cerulli, Scott, Aunap, Kull, & Pärn, 2020) Early warning systems (EWS) are only helpful if they essentially and enthusiastically put people at the centre – confirming all elements of the early EWS deem and prioritise those at risk from natural hazards (World Meterological Organization, 2010). Community-based EWSs are good examples involving local communities (Šakić, et al., 2022).

The construction of coastal embankments in Bangladesh has significantly reduced the impact of cyclones on rural communities. These embankments protect agricultural land and human settlements from storm surges, thus enhancing the resilience of rural populations (Karim & Mimura, 2008).

One of the significant challenges in post-disaster recovery is the allocation of adequate resources and funding. Competing priorities and limited budgets can hinder comprehensive livelihood restoration efforts. Ensuring transparent and efficient use of resources is crucial for the success of these programs (Olshansky & Johnson, 2010).

Rahman and Hossain (2014) discuss the significant role of social capital, particularly bonding, bridging, and linking networks, in enhancing community resilience during floods in rural Bangladesh. They highlight how these networks contribute to

disaster resilience by fostering social cohesion and collective action in affected communities (Rahman & Hossain, 2014).

Different geographical regions in Bangladesh reveal significant regional variations observed in specific climatic challenges. Coastal areas, like Khulna and Satkhira, focus on structural measures such as cyclone shelters and embankments, alongside promoting saline-resistant crops and aquaculture to combat salinity intrusion (Ahmed & Neelormi, 2010) (Islam & Walkerden, 2015). Riverine and floodplain regions prioritise flood management through early warning systems and community-based response plans while innovating agricultural practices with flood-tolerant rice varieties and floating gardens (Mirza, 2003) (Karim, Hussain, & Ahmed, 1996).

4. Materials and Methods

4.1 Research Design

The research employed a mixed-method approach, combining quantitative and qualitative methodologies to gather comprehensive study data. Quantitative data collection utilised a questionnaire administered face-to-face interviews with vulnerable community members in selected areas. Quality assurance measures included rigorous training of field researchers, spot checks, and supervision. Data was collected using KoboToolbox for validation and consolidation. Qualitative data was gathered through participatory action research tools such as Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) to explore climate impacts and identify gender-responsive adaptation options. This holistic approach ensured a thorough understanding of socio-economic, demographic, and climate-related factors influencing vulnerability and adaptation needs.

Table 1: The Study Area

Division	Districts	Upazila	Unions	Village	Vulnerability
Rangpur	Kurigrarn	Fulbari	Borovita	1. Banglabazar 2. Lombagram 3. Dokkhin Boroloi	1. Flood 2. Riverbank erosion
Rajshahi	Naogaon	Shapahar	Tilna	1. Ilimpur 2. Chakgopal 3. Jinarpur	1. Drought
Khulna	Satkhira	Shyamnagar	Munshiganj	1. Dokkhin Kodomtola 2. Central Kalinagar 3. Chonkuri	1. Cyclone 2. Salinity 3. Sea level rise

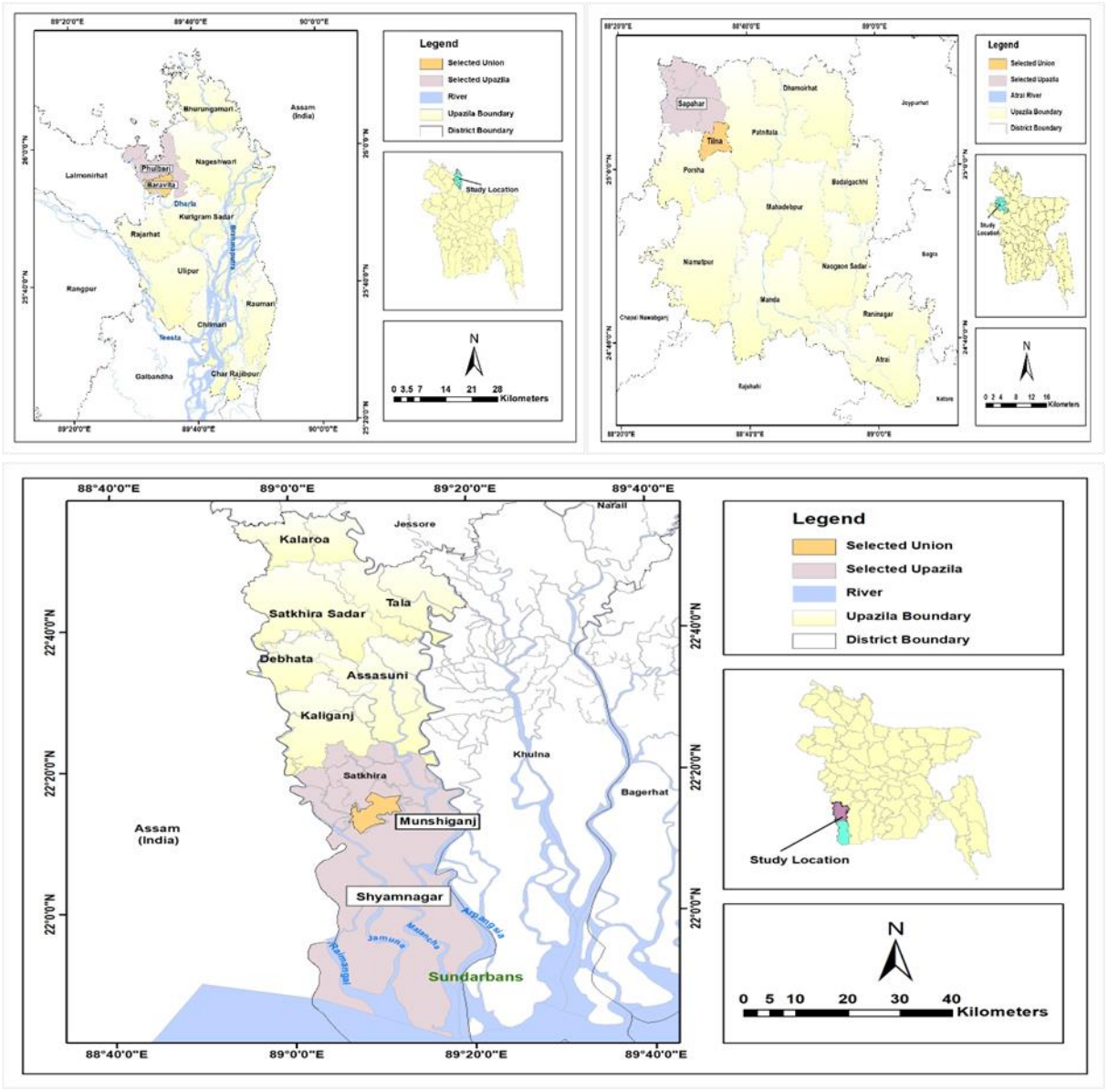

Figure 1: Study Area Map

4.1.2 Data Sources and Selection Criteria

The research study employed quantitative and qualitative data sources to obtain comprehensive insights into adaptive strategies and livelihoods within the study areas. Quantitative data was acquired through a household survey utilising a structured questionnaire designed for vulnerable community members. Sample size determination followed statistical formulas and multi-stage cluster sampling techniques, ensuring representative coverage. For sample selection, the following statistical formula was used,

$$n_0 = \frac{Z^2 pq}{d^2}$$

Where,

n_0 = desired sample size,

Z = standard normal deviate usually set at 1.96, which corresponds to the 95% confidence interval,
p = proportion in the target population estimated to have a particular characteristic, and here it takes to be 0.50 such that p + q = 1,
d = desire precision (here, desire precision is considered 5%, i.e., 0.05).

Putting those values in the above formula, we got,

$$n_0 = \frac{Z^2 pq}{d^2}$$

$$= \frac{(1.96)^2 \times 0.50 \times 0.50}{(0.05)^2}$$

$$= 384.16 \approx 384$$

As per the Bangladesh National Portal, the total population of the three unions is 85235. So, this sample needed to be adjusted by using the following formula,

$$n = \frac{n_o}{1+\frac{(n_o-1)}{N}}$$

Where,
n = desired sample size after adjustment
n_0 = primary sample size
N = known population

After putting in the value, we got 382. Here, the design effect has been considered as 1.4. So, the sample size multiplied by 1.4 is equal to 535. The 5% non-response of 535 is 27, and the total sample was 562.

Qualitative data was gathered through 18 Focus Group Discussions (FGDs) in 9 targeted villages with both women and men and 17 Key Informant Interviews (KIIs) with the different stakeholders, including the influencing persons in the community like Union Chairman, Ward Member, teacher, religious leader, local administration, and NGO professionals in the selected study areas. Secondary data from literature reviews supplemented the analysis. Selection criteria prioritised vulnerability, gender responsiveness, and representation of diverse community perspectives.

Table 2: Household Survey Sample Distribution

SL	Division	District	Upazila	Union	Village	# of respondents
1	Rangpur	Kurigrarn	Fulbari	Borovita	3	187
2	Rajshahi	Naogaon	Shapahar	Tilna	3	187
3	Khulna	Satkhira	Shyamnagar	Munshiganj	3	188
Total	**3**	**3**	**3**	**3**	**9**	**562**

4.2 Data Analysis Techniques

Quantitative data analysis entailed summarising household-level data through descriptive statistics. Statistical software such as SPSS, R, Stata, and Excel facilitated data cleaning, analysis, and visualisation. Organised into a distinct database, qualitative data underwent thematic analysis after converting open-ended responses into scripted formats. Triangulation of qualitative and quantitative findings ensured the robustness and validity of inferences drawn. Content analysis further contextualised information, offering actionable insights and effectively representing factual evidence. This comprehensive approach facilitated a nuanced understanding and interpretation of the study's findings.

5. Results and Discussion

According to the survey findings (Table 3), diverse livelihood types are prevalent across all study areas. Specific livelihood options unique to the Satkhira region include Crab Collection, Crab Fattening, Forest Resource Collector (Bawali/Mouali), and Shrimp Culture, with response percentages of 12, 8.7, 4.2, and 12.3 respectively. Furthermore, mango cultivation and mango-related businesses are notably prominent in the Naogaon area, representing 10% of the total responses.

Table 3: Existing Livelihood Options in the Study Area

Existing livelihood options in the study area (% within the district)			
	Name of the District		
Livelihood options	**Satkhira**	**Naogoan**	**Kurigram**
Agricultural crop production/farming	6.2%	13.2%	18.2%
Agriculture wage labour	6.2%	12.7%	17.0%
Motorcycle driver	6.4%	0.7%	1.3%
Business	6.2%	8.4%	8.1%
Crab collection	12.0%	0.0%	0.0%
Crab fattening	8.7%	0.0%	0.0%
Dairy business	0.3%	3.7%	3.6%
Fish farming	8.4%	3.4%	5.3%
Food for work/money (soil cutting, road maintenance etc.)	5.5%	6.5%	4.8%
Forest resource collector (bawali/mouali)	4.2%	0.0%	0.0%
Fruit production	0.4%	5.0%	2.4%
Fry collection	6.0%	0.0%	0.4%
GO service	0.1%	1.3%	0.6%
Handicraft (swing, handloom, cottage, etc.)	0.0%	0.7%	1.4%
Housemaid	0.0%	2.5%	0.5%
Livestock and poultry	3.6%	7.9%	7.8%
Mango cultivation & business	0.0%	10.0%	0.2%
Money lending	0.0%	0.5%	1.3%
NGO worker	0.6%	2.7%	3.2%
Non-farming day labour	4.5%	4.4%	5.6%
Shrimp culture	12.3%	0.0%	0.6%
Tailor	1.1%	3.0%	3.7%

Teaching	0.9%	3.0%	3.6%
Timber business	1.0%	3.2%	3.8%
Transport driver (rickshaw/van/cart/boatman)	5.4%	6.9%	6.2%
Others (specify)	0.0%	0.1%	0.2%

Note: Percentages are based on responses from the survey sample

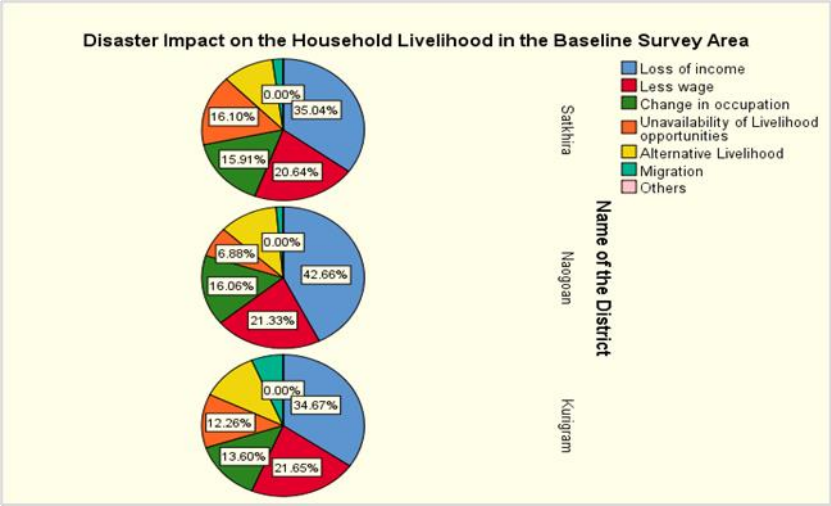

Figure 2: Distribution of the Disaster Impacts on the Household Livelihood

The depicted figure (refer to Figure 2) illustrates how disasters have affected household livelihoods across six categories. Naogaon demonstrates the highest degree of impact, with 42.7% reporting income loss, followed by Satkhira (35.0%) and Kurigram (34.7%). Moderate effects are observed regarding wage reduction, occupation change, and alternative means of subsistence, with all three districts exhibiting similar patterns. Moreover, disasters exert a more pronounced influence on livelihood opportunities in Satkhira (16.1%) and Kurigram (12.3%) compared to Naogaon (6.9%). Migration displays the least impact on disaster across the three districts.

The provided table (refer to Table 4) illustrates the extent of adaptation practices employed to mitigate the impact of disasters on livelihoods. The prioritised adaptation techniques vary across districts. In Satkhira, the most emphasised practices include taking out loans (20.6%), utilising savings (18.5%), pursuing multiple earning sources (17.3%), and exploring alternative livelihoods (17.1%). Conversely, in Naogaon, the focus is on seeking various earning sources (24.5%), engaging in income-generating activities (21.9%), and exploring alternative livelihoods (21.1%). Similarly, in Kurigram, significant emphasis is placed on alternative livelihoods (22.2%), savings utilisation (19.4%), and seeking multiple earning sources (18.3%).

Table 4: Distribution of the Adaptation Practice to Reduce Disaster Impact on the Livelihood

Adaptation practice to reduce disaster impact on the livelihood (% within the district)			
	Name of the District		
	Satkhira	**Naogoan**	**Kurigram**
Alternative livelihood	17.1%	21.1%	22.2%
Searching for multiple earning sources	17.3%	24.5%	18.3%
Income generating activity	15.0%	21.9%	12.7%
Use savings	18.5%	11.7%	19.4%
Application of advanced technologies	1.2%	1.7%	2.8%
Changing the cropping pattern	0.2%	0.2%	0.2%
Taking loans	20.6%	14.9%	14.5%
Take relief / financial assistance	9.7%	4.0%	7.3%
Migration	0.4%	0.0%	2.2%
Others	0.0%	0.0%	0.4%
a. Dichotomy group tabulated at value 1.			

Note: Percentages and totals are based on responses.

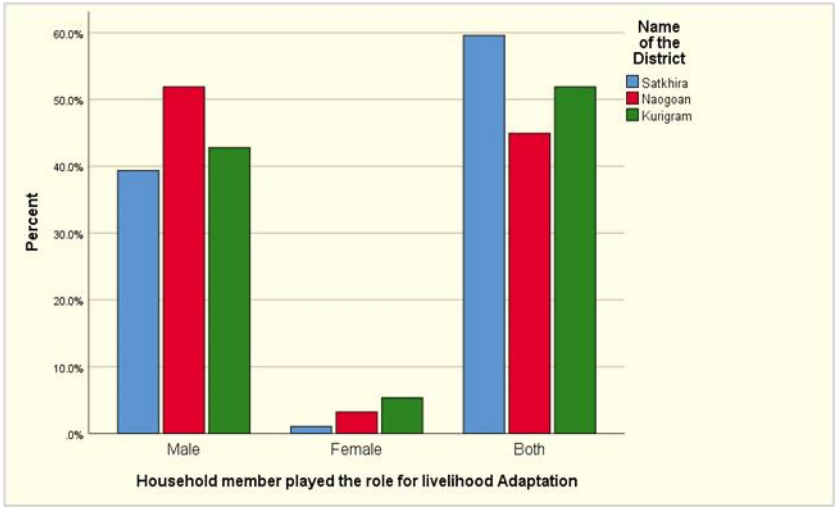

Figure 3: Percentage Distribution of the Role Played for Livelihood Adaption

The survey findings (refer to Figure 3) suggest that males were more prominently involved in livelihood adaptation within the Naogaon region. Conversely, female household members in the Kurigram area exhibited greater involvement in livelihood adaptation compared to those in Satkhira and Naogaon. Both males and females contributed to livelihood adaptation roles in Satkhira, accounting for almost 60% of participation, a figure higher than observed in the other two regions.

The survey data (refer to Table 5) reveals a relatively low overall percentage of individuals receiving or receiving livelihood support across the three study areas, standing at 2.7%. Kurigram exhibits the highest access rate to livelihood assistance at 3.7%, followed by Satkhira at 3.2%, albeit slightly lower than Kurigram. However, Naogaon lags with only 1.1%, highlighting a noticeable disparity between Naogaon and the other two districts.

Table 5: Percentage Distribution of the Receiving Livelihood Support

Getting or got any livelihood support (% within the name of the district)					
		Name of the District			**Total**
		Satkhira	**Naogoan**	**Kurigram**	
Getting or got any livelihood support	Yes	3.2%	1.1%	3.7%	2.7%
	No	96.8%	98.9%	96.3%	97.3%
Total		100.0%	100.0%	100.0%	100.0%

Table 6 delineates the distribution of livelihood support across six categories: Livelihood Training, Financial Assistance, Land Support, Tools & Equipment, Raw Materials, and Others. Notably, in Naogaon, all livelihood support is provided through financial assistance. Conversely, support manifests in various forms in the Satkhira and Kurigram districts. Specifically, Satkhira receives 50.0% and 33.3% in financial assistance and livelihood training, respectively, while Kurigram obtains 45.5% and 27.3% in these categories. Additionally, Kurigram receives 9.1% individually in land support, tools and equipment, and raw materials, whereas the other two districts do not receive support in these categories. Moreover, Satkhira gets 16.7% of different forms of livelihood support.

Table 6: Distribution of the Types of Livelihood Support

Types of livelihood support (% within the district)				
	Name of the District			**Total**
Types of livelihoods support	**Satkhira**	**Naogoan**	**Kurigram**	
Livelihood training	33.3%	0.0%	27.3%	5
Financial assistance	50.0%	100.0%	45.5%	10
Land support	0.0%	0.0%	9.1%	1
Tools & equipment	0.0%	0.0%	9.1%	1
Raw materials	0.0%	0.0%	9.1%	1
Others	16.7%	0.0%	0.0%	1
Percentages and totals are based on responses.				
a. Dichotomy group tabulated at value 1.				

The findings depicted in Figure 4 illustrate that Kurigram ranks highest in terms of both practical and sustainable livelihood support, accounting for 40.00%, followed by Satkhira at 13.33% and Naogaon at 6.67%. Conversely, Satkhira occupies the top position with 20.00% for effective but not sustainable livelihood support, while Naogaon and Kurigram share the same percentage at 6.67%. However, in Satkhira, 6.67% of respondents received neither effective nor sustainable livelihood support.

Table 7 illustrates that the overall knowledge rate concerning climate-resilient livelihoods across the three districts is relatively low, at 95.6%. However, among the districts where awareness exists, Satkhira ranks highest at 6.4%, followed by Kurigram and Naogaon at 5.9% and 1.1%, respectively.

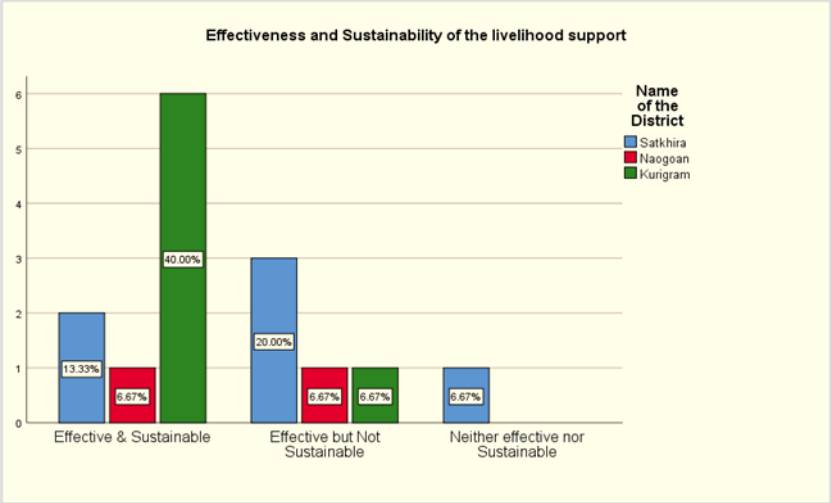

Figure 4: Percentage Distribution of Effective and Sustainable Livelihood Support

Table 7: Percentage Distribution of Knowledge About Climate-resilient Livelihood

Know about climate-resilient livelihood				
(% within the district)	**Name of the district**			**Total**
	Satkhira	**Naogoan**	**Kurigram**	
Yes	6.4%	1.1%	5.9%	4.4%
No	93.6%	98.9%	94.1%	95.6%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**

The survey findings presented in Table 8 indicate that the overall prevalence of required climate-resilient livelihood options across the three districts is minimal, totalling 73.0%. Among the districts, Kurigram exhibits the highest rate at 35.3%, followed by Satkhira at 28.2%, while Naogaon records the lowest rate at 17.6%.

Table 8: Distribution of the Requirement for More Climate-resilient Livelihood Options

Required climate-resilient livelihood options (% within the name of the district)					
		Name of the district			**Total**
		Satkhira	**Naogoan**	**Kurigram**	
Required more climate-resilient livelihood options	Yes	28.2%	17.6%	35.3%	27.0%
	No	71.8%	82.4%	64.7%	73.0%
Total		**100.0%**	**100.0%**	**100.0%**	**100.0%**

As depicted in Table 9, the survey findings underscore the support required for climate-resilient and sustainable livelihood options. Financial assistance and training emerged as the most sought-after support across all three districts. In the Satkhira district, technical support ranks third in demand (25.9%), followed by resource support (15.9%), with Naogaon displaying a similar trend. Conversely, in the Kurigram district, training (23.1%) surpasses technical support (13.3%) in demand.

Table 9: Percentage Distribution of the Types of Support Required for Climate-resilient Livelihood Options

Types of support wanted for the mentioned climate resilient (& sustainable) livelihood option				
		Name of the District		
		Satkhira	Naogoan	Kurigram
Types of support required	Financial	30.0%	30.3%	33.5%
	Technical	25.9%	16.2%	13.3%
	Training	28.2%	32.3%	23.1%
	Resource	15.9%	21.2%	30.1%
a. Dichotomy group tabulated at value 1.				

Note: Percentages and totals are based on responses.

6. Major Recommendations

These recommendations leverage the districts' unique socio-economic and environmental contexts, fostering resilience and empowering communities to adapt sustainably to climatic disasters.

6.1 Promote Ecosystem-Based Adaptation (EBA) Strategies

- Implement EBA practices like mangrove restoration in Satkhira to mitigate cyclone and salinity impacts. In Naogaon, focus on agroforestry to enhance drought resilience, and in Kurigram, promote wetland restoration to buffer against flooding.
- Foster community participation in the planning and maintaining these ecosystems to ensure sustainability and enhance local ownership.

6.2 Develop and Disseminate Climate-Resilient Agricultural Practices

- Introduce and train farmers in climate-smart agricultural techniques such as salt-tolerant crop varieties in Satkhira, drought-resistant crops in Naogaon, and flood-tolerant rice in Kurigram.
- Support these initiatives with access to climate-resilient seeds and farming tools, ensuring these inputs are affordable and accessible to marginalised farmers.

6.3 Strengthen Local Climate Information Services

- Establish localised weather stations and enhance the distribution of weather forecasts and early warning systems through mobile technology. This will help farmers and local communities make informed decisions about crop planting, harvesting, and disaster preparedness.

6.4 Support Diversified Livelihood Opportunities

- Encourage non-agricultural income-generating activities such as handicrafts, eco-tourism, and small-scale agro-processing industries that can provide alternative income sources during off-seasons or in the aftermath of climatic events.

6.5 Expand Microfinance and Insurance Coverage

- Facilitate access to microfinance services that offer flexible repayment schedules adjusted for disaster impacts. Develop insurance products tailored to the needs of rural communities facing high disaster risks, including index-based insurance schemes.

6.6 Enhance Community Infrastructure to Withstand Disasters

- Invest in disaster-resilient infrastructure such as raised grain storage facilities in flood-prone areas, improved drainage systems in areas susceptible to water logging, and cyclone shelters in coastal regions.

6.7 Incorporate Traditional Knowledge with Modern Practices

- Document and integrate traditional adaptation strategies with scientific research to develop culturally acceptable and technologically effective solutions.
- Organise community workshops where elders can share traditional coping strategies with younger generations, supplemented by expert guidance on enhancing these practices with modern technology.

6.8 Promote Gender and Socially Inclusive Disaster Risk Management

- Ensure that adaptation and disaster risk reduction programs are inclusive by actively involving women, youth, and marginalised groups in decision-making.
- Develop targeted training and capacity-building programs that address these groups' specific vulnerabilities and capacities.

6.9 Form Public-private Community Partnerships to Drive Sustainable Development

- Engage local businesses, NGOs, government, and international donors in partnerships that leverage each entity's strengths to build resilience at the community level.
- These partnerships could focus on scaling up successful pilot projects, securing sustainable funding, and enhancing the local capacity for adaptation.

7. Conclusion

The research on adaptive strategies and livelihoods in Bangladesh's Satkhira, Naogaon, and Kurigram districts elucidates the nuanced dynamics between community resilience and the relentless challenge of natural disasters. While each district displays unique environmental adversities and adaptive responses, the collective findings underline the critical need for tailored, sustainable support structures that integrate financial, technical, and educational resources. The data reveals that despite some successes in adaptation, significant gaps in support and knowledge about climate-resilient livelihoods persist, emphasising the necessity for continued investment in these communities.

Future research should extend beyond the current geographical focus to encompass a broader range of disaster-prone and vulnerable areas, facilitating a deeper understanding of regional disparities and the efficacy of localised adaptation strategies. Such studies are vital for crafting reactive and proactive policies, anticipating the needs of and harnessing the potential of at-risk populations. Enhancing the granularity of data on community-driven adaptation measures can significantly inform the scalability and applicability of successful strategies across different contexts.

Moreover, longitudinal studies would help track the long-term effectiveness of these adaptations and the evolving nature of community resilience in the face of climatic changes. By expanding research to include more diverse and extensively affected regions, stakeholders can better identify critical leverage points for intervention, ensuring that resilience-building efforts are inclusive and effective. This approach will ultimately contribute to the robustness of disaster management frameworks, promoting sustainability and the well-being of vulnerable populations in Bangladesh and similar settings globally.

Conflict of Interest Statement

The authors of this research study, titled "Local Responses to Climatic Disasters: Adaptive Strategies for Sustainable Livelihoods in Satkhira, Naogaon, and Kurigram", state that there are no conflicts of interest that could be alleged to affect the neutrality, objectivity, or integrity of this research. The research was conducted to contribute to the academic understanding of the local responses to climatic disasters.

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